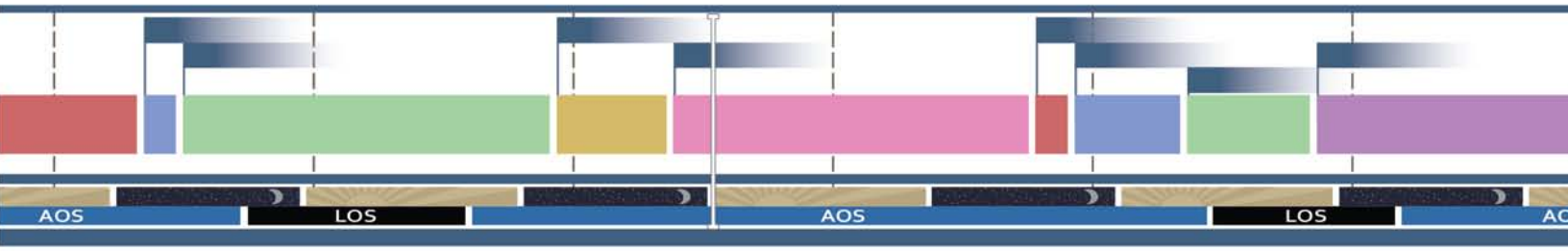


Console Handbook

ADCO

Attitude Determination and Control Officer

The ADCO (pronounced *add-co*) flight controller works together with a Russian flight controller counterpart to calculate and manage the attitude (or orientation) of the International Space Station (ISS). The ADCO flight controller also plans upcoming orientations and attitude maneuvers, and visiting vehicle dockings to the ISS. This person monitors the ISS position, velocity (speed and direction) and attitude to make sure that they do not change unless commanded to do so by the computers aboard the ISS.

ADCO

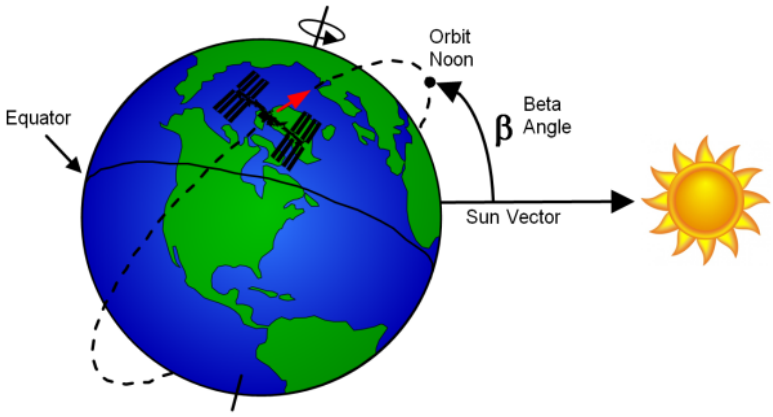
Attitude Determination and Control Officer

System Managed: Guidance, Navigation and Control (GNC) System

Guidance

Where do I want to go? How do I want to be oriented?

The ADCO flight controller manages the guidance of the ISS. To guide the ISS properly, the flight controller works to keep it in a stable, nearly circular, orbit around the Earth. The orbit is defined by how high the ISS is above the surface of the Earth and the angle of its orbital path with respect to the equator.



The flight controller also guides the ISS by planning changes to the attitude (orientation) for various activities, such as the docking and undocking of visiting vehicles.

Navigation

Where am I? How am I currently oriented? Where is everything else?

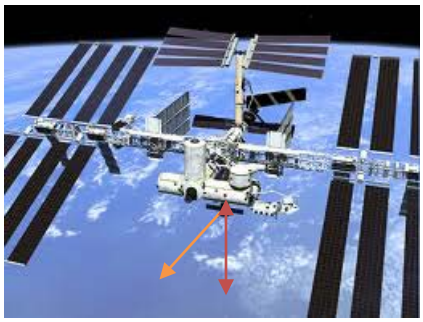
The ADCO flight controller manages the navigation of the ISS; which means maintaining a current estimate of the ISS position, velocity and attitude.

State Determination

Where am I?

The ISS state determination uses a Global Positioning System (GPS) receiver similar to the GPS system in a car or mobile phone. This GPS receiver keeps track of the ISS position and velocity at all points in the orbit.

To learn more about how a GPS works, view the NASA *Launchpad: How GPS Works* video at http://www.youtube.com/watch?v=DsmvTzw3GP4&feature=youtu.be.



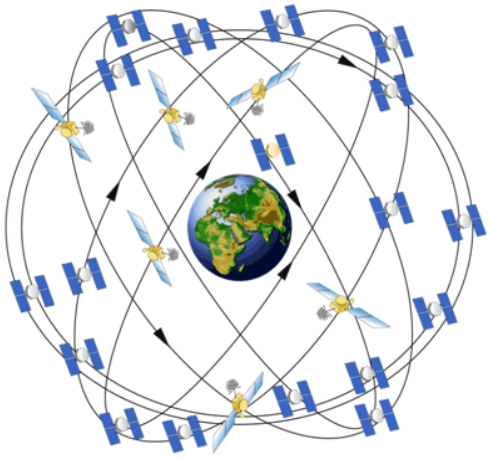
Position = How high and where the ISS is located above the Earth, which averages between 340 and 420 kilometers (210 and 260 miles).

Velocity = How fast and in which direction the ISS is traveling in its orbit around Earth, which averages 27,700 kilometers per hour (17,225 miles per hour).

Attitude Determination

How am I currently oriented?

The ISS also uses GPS to determine how the ISS is oriented, or facing, as it orbits the Earth. This orientation, or attitude, can be determined by measuring the difference in time that the GPS signals are received by four antennas. These antennas receive the same GPS signal at slightly different times, with the signal traveling at a constant speed (the speed of light).

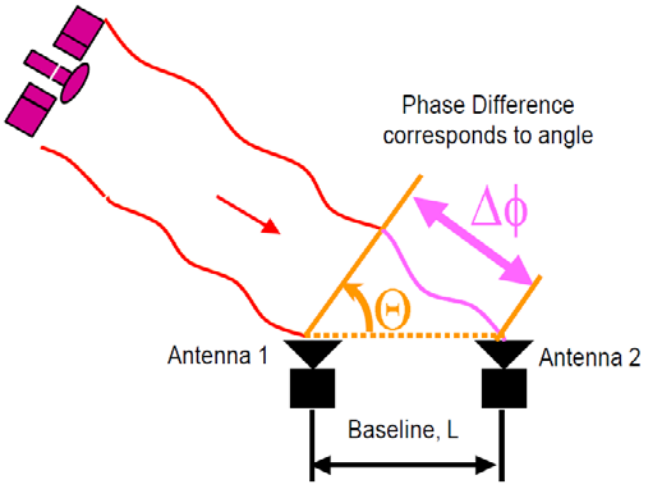


To calculate attitude, at least four of the nearly 24 GPS satellites in orbit must be in view of these antennas. The GPS receiver calculates the ISS attitude about once a minute, providing information on where the ISS is pointed at that point in time.

Pointing Data

Where is everything else?

The Guidance, Navigation and Control (GNC) System uses the current position, velocity and attitude of the ISS to calculate the angles formed between the ISS and the Sun, Earth and communication satellites. This information (called pointing data) is sent to other ISS systems, and is used to help properly point the antennas, solar arrays, cameras and other instruments.



Control

How do I get to the preferred orbit? How do I get to the preferred attitude?

While guidance means deciding on a path the ISS needs to take in order to stay in or reach a position or attitude in orbit, controlling the ISS means determining what is needed to move it along this path.

Translational Control

How do I get to the preferred orbit?

Over time, any spacecraft orbiting the Earth will slow down. Even though the ISS is in space, it is not in a complete vacuum, so there is still a tiny amount of air molecules to slow it down. As the ISS slows down, it begins orbiting closer to Earth. About once a month, the ISS must

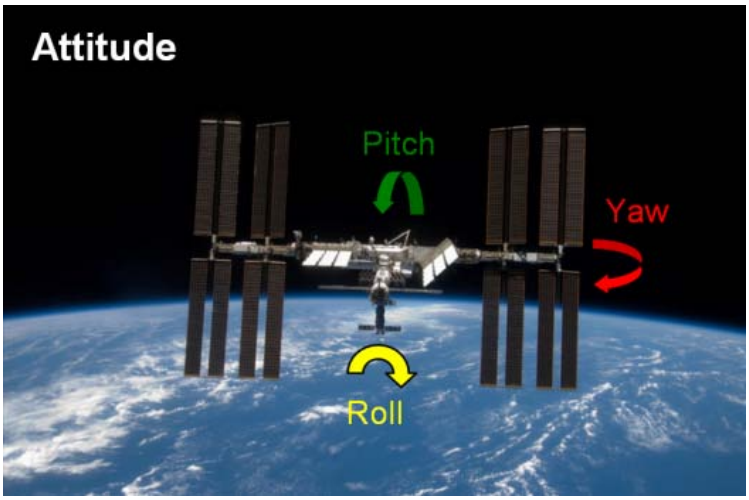
reboost to keep it from falling to Earth. A reboost uses large engines on the ISS to increase the speed and put it into a higher orbit.

To learn more about what happens to crewmembers and equipment during an ISS reboost, view the NASA demonstrational video, *ISS Reboost,* at http://www.youtube.com/watch?v=ZkdfkRC4DbA&feature=player_embedded.

Attitude Control

How do I get to the preferred attitude?

The attitude is how the ISS faces in three-dimensional space. This orientation is defined by the yaw, pitch and roll angles with respect to a reference frame.



Attitude control keeps the ISS pointing in the proper direction and maintains the microgravity environment needed for scientific research. Main control of the ISS attitude is provided by four Control Moment Gyroscopes (CMGs).

The CMGs are used more often than the rocket engines to control the ISS attitude because the gyroscopes do not require propellant, which is expensive to launch to the ISS. Instead, the CMGs use power generated by the solar panels. Similar to a toy gyroscope, each CMG contains a wheel which spins very fast. By pointing the wheels in different directions, the CMGs can either rotate the ISS, or prevent it from rotating.

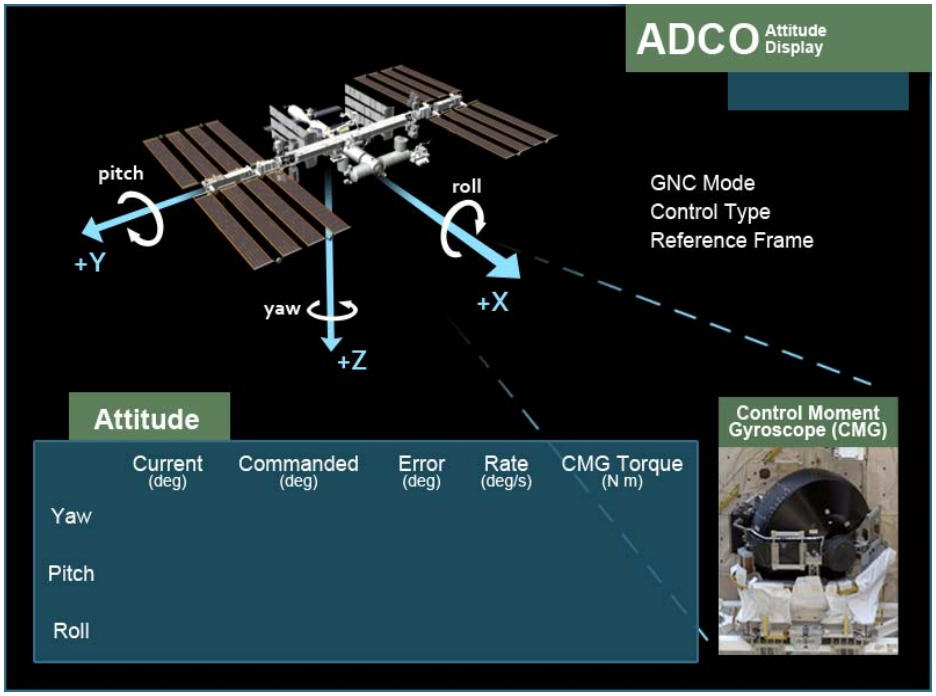
To learn more about how CMG's work:

- Visit http://www.boeing.com/defense-space/space/spacestation/systems/guidance_navagation_control.html,
- or view this video, *Cool New Space Station Parts*, at http://www.youtube.com/watch?v=PBhupmu7EkI&feature=youtube_gdata.

To learn more about guidance, navigation and control systems on the ISS, return to the ISS*Live!* website at http://www.spacestationlive.jsc.nasa.gov. Select "Interact", and then select "Visit Space Station".

ADCO Console Display

A wireless signal sends data from the ISS to the Mission Control Center. This data is updated on the ADCO console display. The ADCO flight controller checks the data on the console display to make sure the GNC system and CMGs are working as expected. The current ISS attitude is displayed in degrees.



Pictured above is a simplified version of the ADCO console display. To view this display, return to the ISS*Live!* website at http://www.spacestationlive.jsc.nasa.gov. Select “Interact”, and then select “Explore Mission Control”.

Space Station Live Data

Would you like to know more about the live data streaming from the ISS to the ADCO console display? Return to the ISS*Live!* website at http://www.spacestationlive.jsc.nasa.gov. Select “Resources”, and then select “Space Station Data”. There you will find a table which includes the names and brief descriptions of all the data values used to update the interactive Mission Control Center console displays.

Acronyms and Abbreviations

ADCO	Attitude Determination and Control Officer
CMG	Control Moment Gyroscope
GNC	Guidance, Navigation and Control (System)
GPS	Global Positioning System
ISS	International Space Station

Glossary of Terms

Altitude	The distance of a spacecraft above the surface of the Earth.
Attitude	The three-dimensional position of a spacecraft in relation to another point. Also called *orientation*.
Control Moment Gyroscopes	Four gyroscopes which maintain the attitude of the ISS.
Data	A set of numbers which shows the value for measurements such as temperature and status: open or closed, on or off.
Force	Causes an object at rest to move, or an object already in motion to move faster or slower.
Gimbal	A device with two mutually perpendicular and intersecting axes of rotation, thus giving free angular movement in two directions.
Global Positioning System	A navigation system made up of satellites and receivers that can determine the latitude and longitude of a receiver by computing the time difference for signals from different satellites to reach the receiver.
Gyroscope	A mechanical device made up of a spinning wheel able to rotate about one or more gimbals.
J2000	The inertial reference frame used by the ISS for navigation. The origin is at center of Earth. The + X axis points toward the mean vernal equinox on January 1, 2000. The +Z axis points toward the north pole along the Earth's mean axis of rotation. The +Y axis completes the right-handed coordinate system.
Microgravity	Near-weightlessness experienced in orbit as a result of the spacecraft "free falling" around the Earth.
Orientation	See *attitude*.
Position	How high and where the ISS is located above the Earth.
Reboost	Engines are fired to boost a spacecraft to a higher altitude.

Satellite	A man-made object that orbits around the Earth.
Solar array	A group of solar cells which collect energy from the Sun and begin the process of converting this energy into power.
Spacecraft	A manned or unmanned device designed to be placed in orbit around the Earth or sent to another celestial body such as a moon or distant planet.
State determination	Determining the position and velocity of a spacecraft.
Three-dimensional	Having three dimensions of length, width and depth.
Translation	Movement in a straight line without rotation.
Vacuum (of space)	An empty volume of space.
Velocity	A quantity equal to the speed an object is moving in a given direction.
Visiting vehicle	Any spacecraft carrying cargo or crew which docks with the International Space Station.